

are from 30 to 40 for triples, and from 33 to 38 for quadruples, but these greatly depend upon the class of vessel. The revolutions per minute are from 75 to 85 for mail boats and 65 to 90 for cargo boats. The piston speeds in feet per minute are from 750 to 950 or 1000 for mail boats with balanced engines, and from 500 to 750 for cargo boats.

Cylinders.—The cylinders, except for the smallest sizes, are always cast separately. In high-class work the cylinders are each provided with a liner of specially hard, close-grained cast iron. The high-pressure cylinder has invariably a piston valve, and the intermediate-pressure cylinder often has some form of balanced slide valve. Low-pressure cylinders have usually a double-ported slide valve, but in some cases piston valves are fitted to all cylinders.

The rules for the thickness of the cylinder walls and of the liners are usually based upon practice, and vary greatly. The question of strength to resist the bursting effect of the steam pressure is obviously the first consideration, especially for the high-pressure cylinder, but allowance must be made for wear and the probable necessity for reboring, and also for the possibility of the casting being thinner in places than intended, due to the core being out of centre. If the low-pressure cylinders were designed only to resist the steam pressure, the metal would come out very thin. Structural stiffness is necessary, and practical considerations in making the casting must be regarded, so that it is usual first to fix the thickness of the high-pressure cylinder and then to make that of the others the same throughout.

Good cast iron, such as is used for cylinders, should bear a stress of 2200 to 2400 lb. per square inch. The thickness of the high-pressure cylinder

may be, therefore, boiler pressure $X - \frac{\text{diameter of cylinder}}{4600} + J$.

For the liner the same rule may be used, but the constant added may be J to $\frac{1}{2}$ in. to allow for reboring. If no liner be used, the thickness of the cylinder barrel may be about the same as that for a liner.

A rule sometimes used is to allow a stress of 1600 lb. per square inch for the high-pressure cylinder, 1000 lb. per square inch for

the intermediate-pressure, and 550 to 600 lb. per square inch, for the low-pressure. Full boiler pressure is assumed on the high-pressure, 70 lb. per square inch on the intermediate-pressure, and 25 lb. per square inch on the low-pressure cylinders. These figures allow for reboring.

The valve chests are usually cast with the cylinders. When piston valves are used they are provided with liners of hard, close-grained metal for the piston valves. When slide valves are used in the low-pressure cylinder, a face of similar metal is used. The ports are kept as short as possible with the object of decreasing the clearance volume.

The speed of the steam through the ports is 5000 to 5500 ft. per minute for the high-pressure cylinder, 6500 to 7000 ft. per minute for the intermediate, and 8000 to 8500 ft. per minute for the low-pressure. The speed through the holes in the valve liners is necessarily higher. The valve diameter and the valve travel should be such that the speed of the entering steam should